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FlowTracker® Handheld ADV® User's Manual Firmware Version 3.7

featuring

SmartQC™

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P/N 6054-60051--D

WARRANTY, TERMS, AND CONDITIONS

Thank you for purchasing a SonTek/YSI FlowTracker. The instrument was thoroughly tested at the factory and found to be in excellent working condition. If the shipping crate appears damaged, or if the system is not operating properly, please contact SonTek/YSI immediately.

The system you have purchased is covered under a one year limited warranty that extends to all parts and labor for any malfunction due to workmanship or errors in the manufacturing process. The warranty does not cover shortcomings that are due to the design, nor does it cover any form of incidental damage as a result of errors in the measurements.

If your system is not functioning properly, first try to identify the source of the problem. If additional support is required, we encourage you to contact us immediately, and we will work to resolve the problem as quickly as possible.

If the system needs to be returned to the factory, please contact SonTek/YSI to obtain a Return Merchandise Authorization (RMA) number. We reserve the right to refuse receipt of shipments without RMAs. We require the system to be shipped back in the original shipping container using the original packing material with all delivery costs covered by the customer (including all taxes and duties). If the system is returned without appropriate packing, the customer will be required to cover the cost of a new packaging crate and material.

CONTACT INFORMATION

Any questions, concerns, or suggestions can be directed to SonTek by telephone, fax, or email. Business hours are 8:00 a.m. to 5:00 p.m., Pacific Standard Time, Monday through Friday.

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1.1. System Components

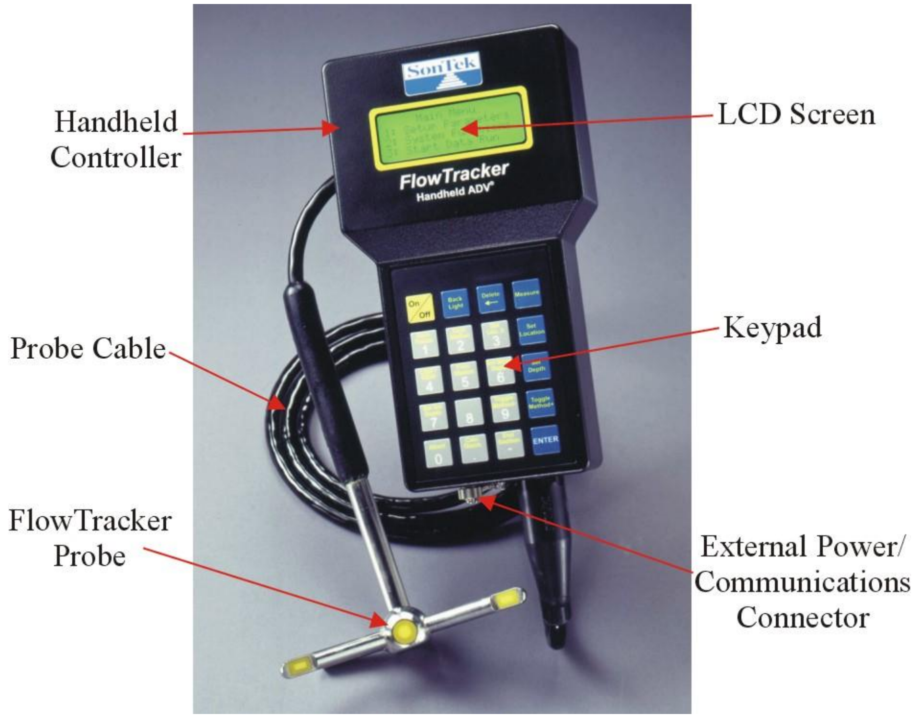


Figure 1 – FlowTracker with 2D Probe

Figure 1 shows the FlowTracker with all major components labeled.

- **Probe** – The probe contains the acoustic elements used to measure velocity. See the *FlowTracker Principles of Operation* for more information.
- **Handheld controller** – The controller is designed to withstand temporary submersion, but is not intended for underwater operation. The battery compartment is on the back.

SmartQC™

The FlowTracker has several QA/QC features designed to increase data integrity. Some of these features have bounds that can be set by the user, while others automatically adapt to the given situation. **SmartQC™** refers to the collective ability of all these features towards helping you make a better measurement. Specific QA/QC features are identified in this manual with the **SmartQC** symbol.

1.2. Battery Power

The FlowTracker uses eight AA batteries: alkaline, NiMH, or NiCad. Table 1-1 lists approximate new-battery operating parameters.

Table 1-1. FlowTracker Battery Types

	Alkaline	**NiMH** (rechargeable)	**NiCad** (rechargeable)
New battery voltage	12.0 V	10.2 V	10.0 V
Approximate operating life	25 hours	15 hours	7 hours

To check FlowTracker battery level and estimated battery capacity:

- Press **5** from the **System Functions Menu**.
- Battery life estimates are at ≈20° C (70° F); cold weather greatly reduces battery capacity. Check battery capacity with the system acclimated to the outside temperature.

The batteries are accessed from the back of the FlowTracker handheld controller (Figure 2). To change the batteries, use the following steps.

- Turn the system off.
- Remove the six screws holding the battery compartment lid to the main housing.
- Remove the old batteries from the battery holder.
- Install the new batteries, matching the orientation shown on the battery holder.
  - Do not mix old and new batteries.
  - Do not mix different types of batteries.
- Secure the battery compartment lid using the six screws.
- Turn the system on and check the battery voltage level to ensure proper installation.

To Avoid Draining Batteries When System is Not in Use

- Always turn the system off before storing the system.
- If the system will not be used for more than one month, remove the batteries.

Figure 2 – FlowTracker Battery Compartment

1.3. Mounting and Installation

SonTek offers top-setting wading rods and mounting brackets for the FlowTracker (Figure 3). The probe is mounted from a special adaptor bracket that offsets the probe to one side of the wading rod, placing the sampling volume closer to the wading rod. The cable from the probe to the handheld controller is highly susceptible to electronics noise and should be treated with care. In any mounting, the cable should be secured to prevent excessive motion or damage.

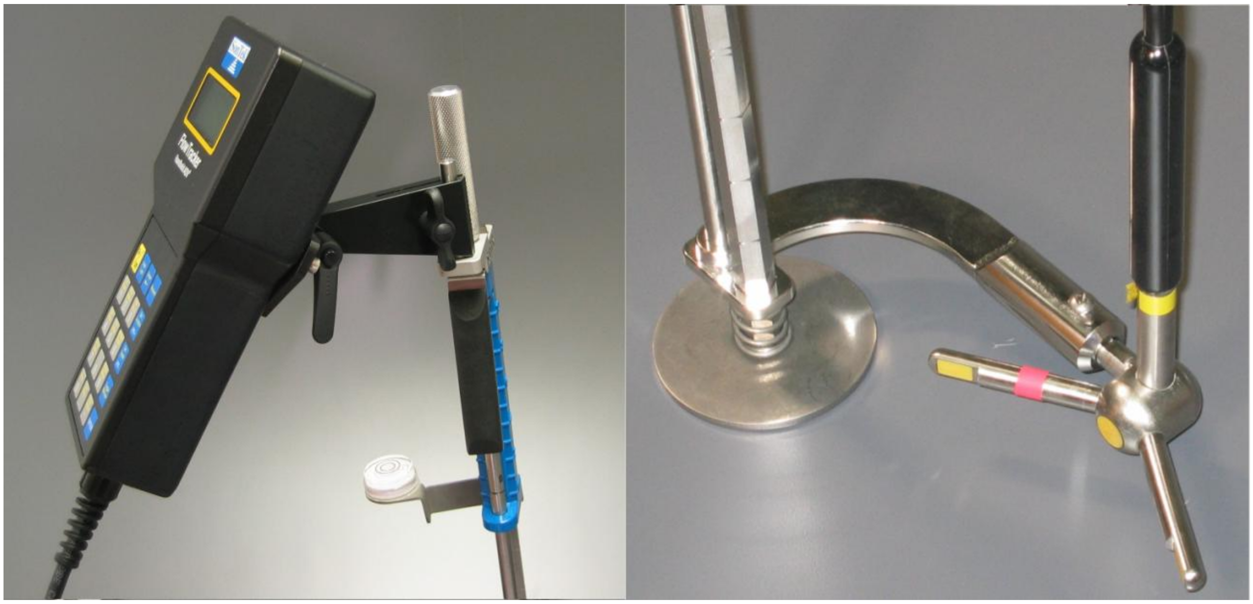


Figure 3 – SonTek Wading Rod

1.3.1. Probe Orientation During Data Collection

Figure 4 shows the proper orientation of the probe for discharge measurements. The tag line is installed perpendicular to the primary flow direction. The FlowTracker X-axis is perpendicular to the tag line (**not** in line with the flow); the red band (which marks receiver arm #1) should face downstream. Figure 5 shows the FlowTracker XYZ coordinate system.

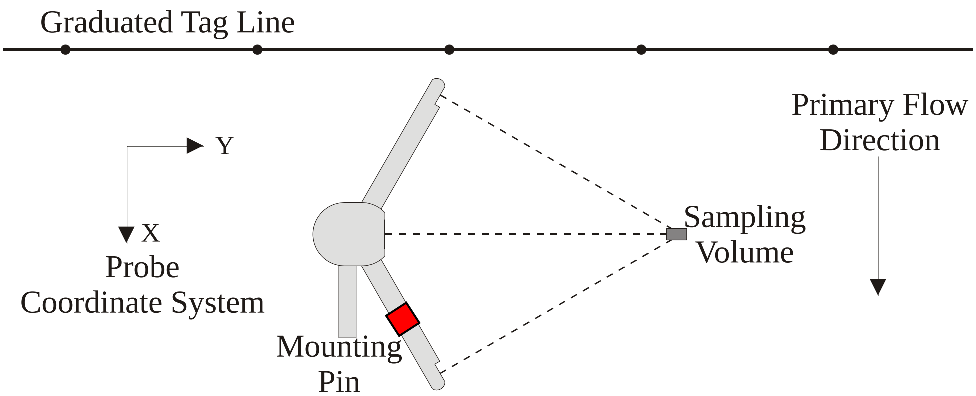


Figure 4 – FlowTracker Probe Orientation Relative to Stream Flow

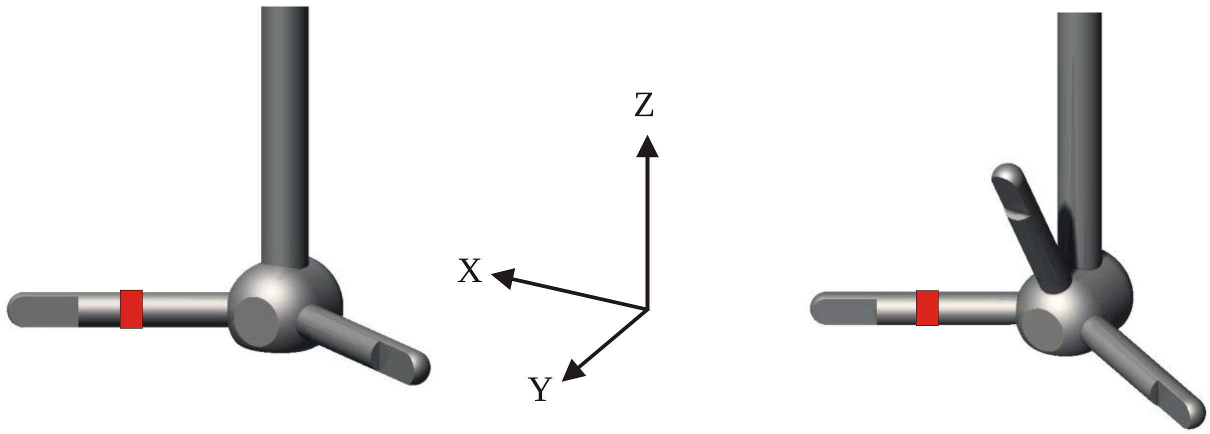


Figure 5 – FlowTracker XYZ Coordinate Systems

1.3.2. Mounting Correction

Laboratory tow tank tests have indicated the FlowTracker probe and mount create flow disturbances that may have a small impact (appoximately 1.0%) on measured velocity data. The mount is most commonly a top-setting wading rod using an S or J offset bracket (Figure 3). Additional tests and modeling have looked at whether flowing water shows the same flow disturbance effect seen in a tow tank (where the FlowTracker is towed through a pool of stationary water). Several independent agencies participated in the review of the test data collected. Some concluded there is not enough data to support applying the correction to typical streamflow measurements, while others concluded that a correction for flow disturbance should be applied. At present, no consensus has been reached on the best way to address this issue for field data collection.

By default, no correction for flow disturbance is applied to FlowTracker data. If you are using a standard top-setting wading rod, and have decided to apply a correction, SonTek typically recommends using a correction of 1.0%. This correction must be applied in both firmware and software to ensure consistent treatment of all data. For additional information about the flow disturbance effect, contact SonTek directly.

To apply a flow disturbance correction, set the **Mounting Correction** from the **Setup Parameters** (§1.6) menu. You must specify the same mounting correction value in software from the **Program Settings** dialog to ensure the correction is applied to processed data.

No Correction

- With the default setting of **No Correction**, the FlowTracker velocity data is used directly without any correction for flow disturbance.

Custom Correction

- This is selected when you want to apply a correction to account for flow disturbance from the FlowTracker mount. With this option, you must specify the value of the **Mounting Correction** within the range -5% to +5%.
- When applied, the most common value for a standard top setting wading rod is 1.0%. A 1.0% correction means that measured velocity data is increased by 1.0% to account for the effect of flow disturbance from the wading rod.
- For additional details, or if using a non-standard mounting system, contact SonTek.

1.4. Keypad

Figure 6 – FlowTracker Keypad

Figure 6 shows the FlowTracker keypad. Many keys serve multiple functions; the use of a few special keys is described below. Special keypad overlays are available in each language supported by the FlowTracker to translated key functions.

On/Off 

- To turn the system on, hold the **On/Off** switch for 1 second until the LCD screen turns on.
- To turn the system off, hold the **On/Off** switch for 4 seconds until the LCD screen resets.

IMPORTANT
Return to the Main Menu <u>before</u> turning the system off to ensure all data is properly saved.

Back Light 

- This key turns the LCD backlight on/off (the backlight turns off after 1 minute).

Letters (A-Z)

- These keys are used to enter text for the filename and for comments in the file.
- Text entry is done in the same manner as for mobile phones.

1.5. Main Menu

When turned on, the FlowTracker displays a wake up screen. Pressing **Enter** displays the **Main Menu**. From the **Main Menu**, press the appropriate key to access the desired function.

- Press **1** for the **Setup Parameters Menu** (see §1.6).
- Press **2** for the **System Functions Menu** (see §1.7).
- Press **3** to start a data run.

```
    Main Menu
1:Setup Parameters
2:System Functions
3:Start Data Run
```

IMPORTANT
Return to the Main Menu <u>before</u> turning the system off to ensure all data is properly saved.

1.6. Setup Parameters Menu (Main Menu <1>)

Setup parameters determine how the FlowTracker collects data (menu screens shown below). Press **Enter** to switch between screens. To change settings, press the number shown.

`1:Units English`
`2:Avg Time (40)`
`3:Mode Discharge`
`0=Exit or Enter=More`
	`4:QC Settings`
	`5:Discharge Settings`
	`6:Salinity (0.00)`
	`0=Exit or Enter=More`
		`7:Language English`
		`8:No Correction`
		
		`0=Exit or Enter=More`

The following settings are available in the **Setup Parameters** menu.

- **Units** – **English** or **Metric** units for display of all data.
- **Avg Time** – the length of data collection for each measurement (10 to 1000 seconds).
- **Mode** – data collection mode as **Discharge** (Section 2) or **General** (Section 3).
- **QC Settings** – settings for automatic review of quality control data (§1.6.1).
- **Discharge Settings** – settings for discharge calculation (§1.6.2).
- **Salinity** – water salinity in ppt, used for sound speed calculations.
  - ***In salt water, install a zinc anode for corrosion protection (available from SonTek/YSI).***
- **Language** – operating language for FlowTracker firmware.
- **Mounting Correction** – the percent correction, if any, applied to velocity data (§1.3.2).

1.6.1. QC Settings (Setup Parameters <4>)

The **QC Settings** menu sets quality control criteria (**Discharge** or **General** mode) (§5.1)

- Press **1** to set the **SNR Threshold**.
- Press **2** to set the **σV Threshold**.
- Press **3** to set the **Spike Threshold**.
- Press **4** to set **Max Velocity Angle**.

1.6.2. Discharge Settings (Setup Parameters <5>)

The **Discharge Settings** menu specifies settings for discharge calculation.

- Press **1** to set the discharge **Equation** (§2.1) – **Mid Section**, **Mean Section**, or **Japanese**.
- Press **2** to toggle **Repeat Depth** (§2.1) between **YES/NO**.
  - Normally used only with the **Japanese** discharge equation.
- Press **3** to toggle **Repeat Velocity** (§2.1) between **YES/NO**.
  - Normally used only with the **Japanese** discharge equation.
- Press **4** to set **Max Section Discharge** (§5.1).
- Press **5** to set **Max Depth Change** (§5.1).
- Press **6** to set **Max Location Change** (§5.1).
- Press **7** to set the discharge **Reference** value.
  - Section discharge (**%Q**) is calculated from either the **Rated** or **Measured** discharge.
- Press **8** to select the **Methods Displayed**.
  - The FlowTracker supports several methods to determine mean velocity (§2.1.4).
  - This selects methods for display when using the **Method +** and **Method –** keys.
- Press **9** to select set the discharge **Uncertainty** calculation (§2.1.5).
  - Two method of uncertainty calculation are supported, **ISO** and **Statistical**.

1.7. System Functions Menu (Main Menu <2>)

The **System Functions** screens are shown below. Press **Enter** to switch between screens. To change settings, press the number shown.

```
1:View Data File
2:Recorder Status
3:Format Recorder
0=Exit or Enter=More
```

```
4:Temperature Data
5:Battery Data
6:Raw Velocity Data
0=Exit or Enter=More
```

```
7:Auto QC Test
8:Show Config
9:Set System Clock
0=Exit or Enter=More
```

The following settings are available in the **System Functions** menu.

- **View Data File** – display data from an already completed file.
- **Recorder Status** – display number of recorded files and remaining space.
- **Format Recorder** – erase all files on recorder.
- **Temperature Data** – display data from FlowTracker temperature sensor.
- **Battery Data** – display battery voltage and remaining battery life.
  - Battery capacity estimates are based on voltage and are only approximate.
  - Cold weather reduces battery capacity; check batteries after the system has acclimated to outside temperatures.
- **Raw Velocity Data** – display raw velocity and SNR data to verify basic system operation.
  - Press **ENTER** to stop data display.
- **Auto QC Test** – an automatic test to verify system operation (§1.7.1).
- **Show Config** – display system serial number, probe type, and firmware version.
- **Set System Clock** – set and change internal FlowTracker clock.

1.7.1. Automatic QC Test

The **Auto QC Test** is an automated version of the *BeamCheck* software (§4.1).

- Place the probe in moving water away from underwater obstacles.
- Data collection and analysis takes ≈30 seconds.
- If any warnings are issued, you are given an option to repeat the test.
  - We recommend repeating the test once, after first checking that the probe and sampling volume are well away from any underwater obstacles.
  - If multiple warnings are received, run *BeamCheck* from a PC (§4.1) to evaluate Flow-Tracker performance in more detail.

1.8. QC Menu

The **QC Menu** is available during data collection for the following functions.

- Input supplemental data
  - Each record includes gauge height, rated flow, a time stamp, and user comments.
- Modify **QC Settings** (§1.6.1).
- Modify **Discharge Settings** (§1.6.2) (**Discharge** mode only).
- Change the averaging time (**Avg Time**) used for each measurement.
- Display **Raw Velocity Data**
- Run and record an additional **Auto QC Test** (§1.7.1).

1.9. Pre-Deployment Diagnostics

Simple diagnostic procedures are provided to verify system operation. *BeamCheck* requires an external computer. Other procedures require only a few minutes and can be performed in the field from the keypad interface. These should be performed before each data run.

BeamCheck:

- *BeamCheck* lets you evaluate all aspects of system performance and should be run before an extended field trip (about once per week).
- Using *BeamCheck* for the first time will require about 30 minutes; experienced users should need about 5 minutes.
- The system must be connected to an external PC. *BeamCheck* details are described in §4.1.

Field diagnostics:

- **Recorder Status** (**2** in **System Functions Menu**)
  - Check available space; download data and format the recorder as needed.
- **Temperature Data** (**4** in **System Functions Menu**)
  - Check temperature data to be sure it is reasonable for the environment.
- **Battery Data** (**5** in **System Functions Menu**)
  - Expected life from new batteries (20°C; 70°F); cold weather reduces capacity.
    - Alkaline: ≈25 hours
    - NiMH: ≈15 hours
    - NiCad: ≈7 hours
- **Raw Velocity Data** (**6** in **System Functions Menu**)
  - Place the probe in the area to be measured.
  - SNR data should ideally be above 10 dB, but at least 4 dB.
  - Velocity data should appear reasonable for the environment.
- **System Clock** (**9** in **System Functions Menu**)
  - Verify the clock is correctly set.

Section 2. Discharge Measurements

Discharge Mode is for applications where the primary goal is to measure river/stream discharge. Section 2.1 describes the measurement methodology and discharge calculations. Section 2.2 describes how to make discharge measurements with the FlowTracker.

2.1. Discharge Calculation Equation

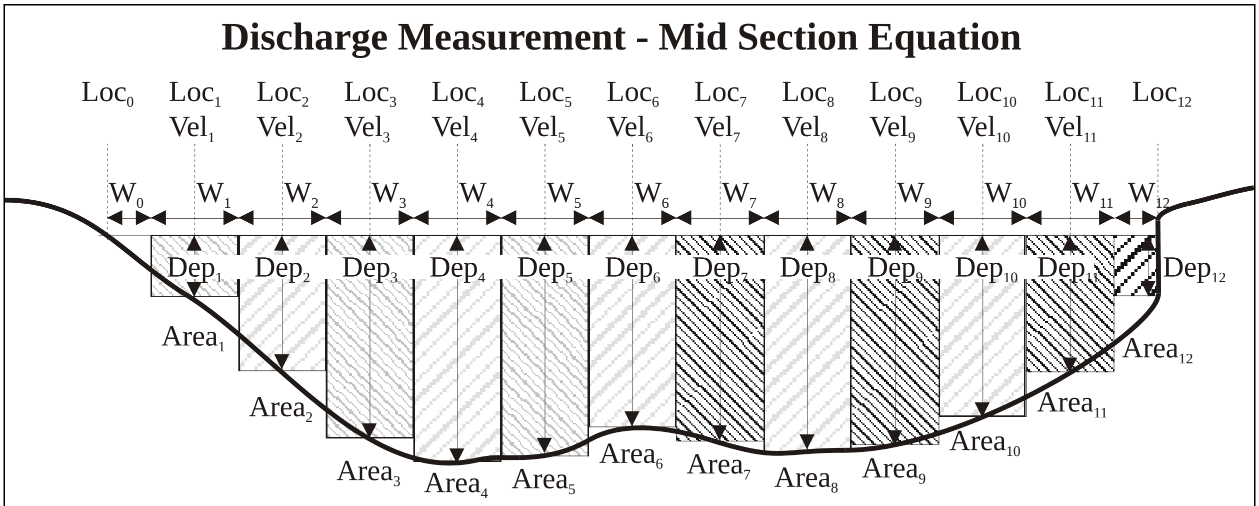
The basic procedure for making a discharge measurement follows.

- A graduated tag line is strung across the river.
- At each station, the operator records the station location and water depth, and takes velocity measurements at one or more depths to determine the mean velocity.
- The probe's X-axis is maintained perpendicular to the tag line (Figure 4).
  - Only the X component of velocity (**Vx**) is used for discharge calculation.

The FlowTracker supports the following equations for calculating discharge – **Mid Section** equation (§2.1.1), **Mean Section** equation (§2.1.2), and the **Japanese** equation (§2.1.3).

2.1.1. Mid Section Discharge Equation

The **Mid Section** discharge equation (Figure 7) is the default and the most commonly used. This method is used by the U.S. Geological Survey (USGS) and is described in ISO standards 748 (1997) and 9196 (1992).



Edge Calculations (Starting, Ending, Internal Island)

i = edge station (Loc_i, Dep_i)
j = adjacent station with velocity (Loc_j, Dep_j, Vel_j)
Edge Width = $W_i = (Loc_j - Loc_i)/2$
Edge Area = $Area_i = W_i * Dep_i$
Edge Correction Factor = CF_i
Edge Velocity = $Vel_i = CF_i * Vel_j$
Edge Discharge = $Q_i = Area_i * Vel_i$

Open Water Calculations

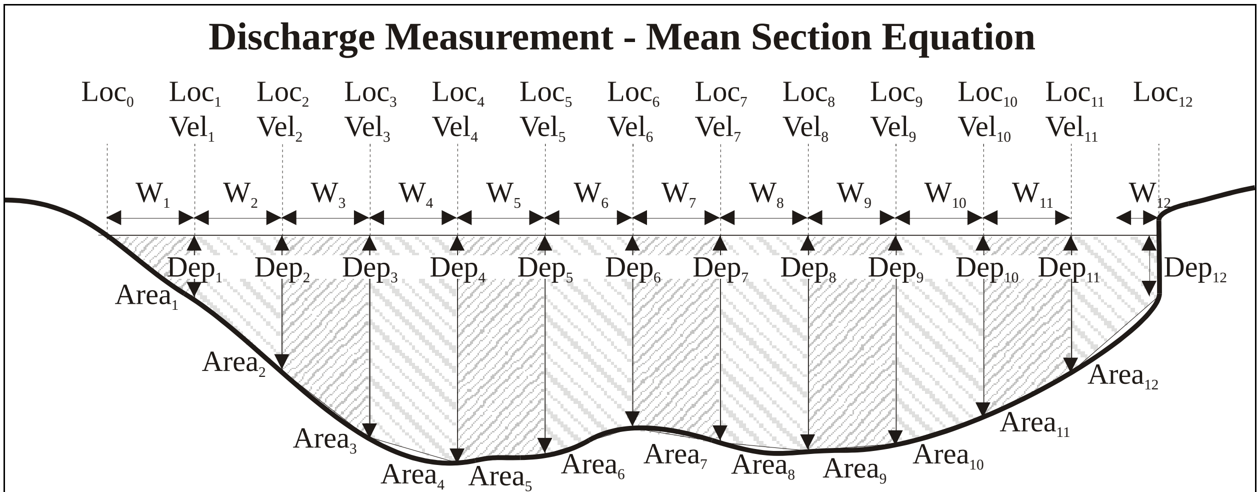
Station Width = $W_i = (Loc_{i+1} - Loc_{i-1})/2$
Station Area = $Area_i = W_i * Dep_i$
Station Velocity = Vel_i
Station Discharge = $Q_i = Area_i * Vel_i$

Total Discharge = Sum(Q_i)

Figure 7 – Discharge Measurement - Mid Section Equation

2.1.2. Mean Section Discharge Equation

The **Mean Section** discharge equation (Figure 8) uses the same data collection procedure as the **Mid Section** equation (§2.1.1), but differs in the details of how discharge is calculated. It is described in ISO standards 748 (1997) and 9196 (1992).



Edge Calculations

Starting edge, second edge of internal island

$Q_0 = W_0 = Area_0 = 0.0$

Ending edge, first edge of internal island

i = edge station (Loc_i, Dep_i)

Edge Width = $W_i = Loc_i - Loc_{i-1}$

Edge Area = $Area_i = W_i * (Dep_i + Dep_{i-1}) / 2$

Edge Correction Factor = CF_i

Edge Velocity = $Vel_i = CF_i * Vel_{i-1}$

Mean Edge Velocity = $MeanV_i = (Vel_i + Vel_{i-1}) / 2$

Edge Discharge = $Q_i = Area_i * Vel_i$

Open Water Calculations

Station Width = $W_i = Loc_i - Loc_{i-1}$

Station Area = $Area_i = W_i * (Dep_i + Dep_{i-1}) / 2$

Mean Station Velocity = $MeanV_i = (Vel_i + Vel_{i-1}) / 2$

Station Discharge = $Q_i = Area_i * MeanV_i$

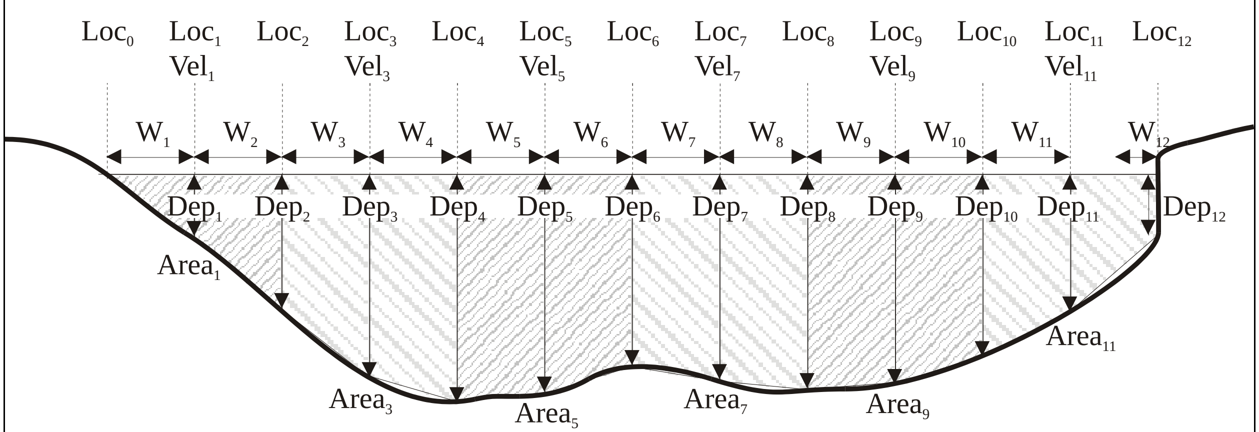
Total Discharge = Sum(Q_i)

Figure 8 – Discharge Measurement - Mean Section Equation

2.1.3. Japanese Discharge Equation

The **Japanese** discharge equation (Figure 9) includes several modifications to the data collection procedures described earlier (§2.1.1, §2.1.2). Velocity is only measured at every second station. Depth for each station is recorded twice; the mean value is used for discharge calculations. Each velocity measurement is repeated twice; the mean is used for discharge calculations.

Discharge Measurement - Japanese Equation



Width, area and discharge are calculated only for stations that include a velocity measurement.

Station Width $W_i = Loc_{i+1} - Loc_{i-1}$

Station Area = $Area_i = ((Loc_i - Loc_{i-1})*(Dep_i+Dep_{i-1}) / 2) + ((Loc_{i+1} - Loc_i)*(Dep_{i+1}+Dep_i) / 2)$

Station Discharge = $Q_i = Area_i * Vel_i$

Total Discharge = $sum(Q_i)$

Figure 9 – Discharge Measurement - Japanese Equation

2.1.4. Determining Mean Station Velocity (Discharge Measurement Method)

The **Method** specifies how the FlowTracker determines mean velocity at each station, involving variations in the number and location of velocity measurements.

- Table 2-1 describes all **Methods** supported by the FlowTracker.
- Select the method using the **Method +** and **Method –** keys.
- **Methods** with more than one measurement can be done in either direction: from surface to the bottom, or from the bottom towards the surface.
- If some **Methods** will never be used, you can specify which methods to display.
    - Press **9** from the **Discharge Settings** menu (§1.6.2).
- All depth values are referenced from the water surface down.
- Effective depth is water depth minus ice depth (water surface to bottom of ice or slush).

Table 2-1. FlowTracker Mean Velocity Methods

Method	Measurement Locations	Mean Velocity Equation
0.6	0.6 * depth	$V_{mean} = V_{0.6}$
0.2/0.8 **0.8/0.2**	0.2 / 0.8 * depth	$V_{mean} = (V_{0.2} + V_{0.8}) / 2$
.2/.6/.8 **.8/.6/.2**	0.2 / 0.6 / 0.8 * depth	$V_{mean} = (V_{0.2} + 2*V_{0.6} + V_{0.8}) / 4$
Ice 0.6	0.6 * effective depth	$V_{mean} = 0.92*V_{0.6}$ (Correction Factor 0.92 can be changed by user)
Ice 0.5	0.5 * effective depth	$V_{mean} = 0.89*V_{0.5}$ (Correction Factor 0.89 can be changed by user)
Ice 2/8 **Ice 8/2**	0.2 * effective depth 0.8 * effective depth	$V_{mean} = (V_{0.2} + V_{0.8}) / 2$
Kreps 2- **Kreps 2+**	0.0 (near surface) 0.62 * depth	$V_{mean} = 0.31*V_{0.0} + 0.634*V_{0.62}$
5 Point- **5 Point+**	0.0 (near surface) 0.2 / 0.6 / 0.8 * depth 1.0 (near bottom)	$V_{mean} = (V_{0.0} + 3*V_{0.2} + 3*V_{0.6} + 2*V_{0.8}+ V_{1.0}) / 10$
Multi Pt	Any number of points at user-specified depths	Integrated velocity average (Figure 10)
None	No velocity measurement	$V_{mean} = CF * V_{adjacent}$
Input V	User input velocity	$V_{mean} = V_{input}$ You can enter an estimated velocity when velocity measurements are not possible (e.g., due to weed growth along a river bank).

There are a few special cases to consider.

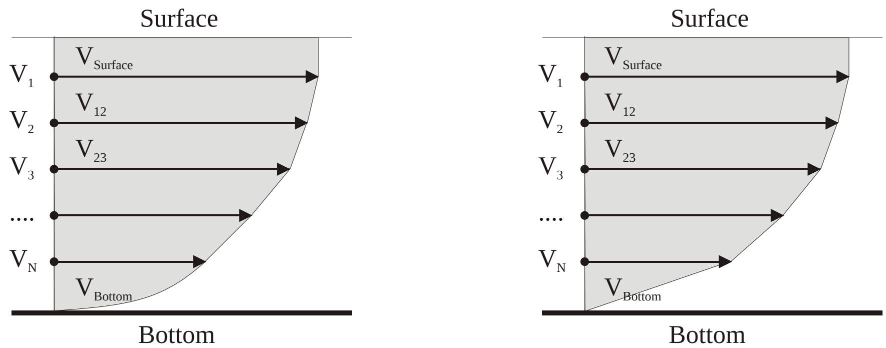
Method **None**

- *Method* **None** is used in two different situations.
  - No measurement is possible and velocity is estimated from adjacent station(s).
  - To specify the banks of an internal island (for a multiple channel river).
- If a single *Method* **None** station is recorded, it is assumed that no measurement was possible.
  - Velocity for this station is based on adjacent station(s) multiplied by the user-specified correction factor (**CF**) for this station. The default **CF** is 1.00.
- If two *Method* **None** stations are recorded together, they are assumed to represent an internal island and discharge is calculated accordingly.

Method **Multi Pt**

- This allows you to make any number of velocity measurements.
  - Manually enter the measurement depth using the **Set Meas Depth** key. Measurement depth should indicate the distance above the bottom.
  - When all measurements are done, press **End Section** or **Abort** to complete the station.
- The mean velocity is calculated by integrating all velocity measurements (Figure 10).
  - If multiple measurements are made at the same measurement depth, these measurements are averaged prior to the velocity integration.

Multiple Point Mean Velocity Integration



Mid and Mean Section Integration

$$V_{Surface} = V_1$$
$$V_{i(i+1)} = (V_i + V_{i+1}) /2$$
$$V_{Bottom} = (6/7)*V_N \quad \text{(1/6 power law)}$$

Japanese Equation Integration

$$V_{Surface} = V_1$$
$$V_{i(i+1)} = (V_i + V_{i+1}) /2$$
$$V_{Bottom} = (1/2)*V_N \quad \text{(linear velocity change)}$$

Figure 10 – Multiple Point Mean Velocity Integration

*Correction Factor (**CF**)*

- **CF** is a user-supplied parameter used to scale the station velocity.
- **CF** is most commonly used at edges, internal islands, and other *Method* **None** stations.
  - The default **CF** value is 1.00.
  - Any value from -1.00 to 1.00, except 0.0, is allowed.
- The **CF** can be input for any station and mean velocity will be multiplied by the **CF**.
  - One possible use is near the edges in very narrow streams; the orientation of the FlowTracker probe can be reversed 180° to allow measurement closer to the edge.
  - A **CF** of -1.00 should be input to correct the FlowTracker X-velocity.
- Incorrect use of this parameter will affect the final discharge measurement.

2.1.5. Discharge Uncertainty Calculation SmartQC

The FlowTracker estimates the uncertainty of every discharge measurement. This calculation can be done using two different ways: **Statistical** or **ISO**.

- The **Statistical** (abbreviated **Stats**) uncertainty calculation uses a method developed by researchers at the U.S. Geological Survery; this is the default calculation as it provides the most reliable indicator of measurement qualtiy.
- The **ISO** method is based on the international standard. It provides users with the results of a published, standard technique; however, in many cases this calculation may not provide a reliable indicator of data quality (see *FlowTracker Technical Manual* for details).

The uncertainty calculations are based on several different parameters. In addition to overall uncertainty, the FlowTracker also looks at the contribution of each parameter.

- **Accuracy**: the accuracy of FlowTracker velocity (this is generally negligible).
- **Depth**
  - In the **Statistical** calculation, this term includes both uncertainty in the depth measurement and the effect of changes in depth between stations.
  - In the **ISO** calculation, this term includes only the uncertainty in depth measurements.

- **Velocity**
  - In the **Statistical** calculation, this term includes both uncertainty in the velocity measurement and the effect of changes in velocity between stations.
  - In the **ISO** calculation, this term includes only the uncertainty in velocity measurements.
- **Width**
  - Estimated uncertainty in width measurements.
- **Method**: Discharge measurement method (§2.1.4)
  - Use for the **ISO** method only.
- **Number of stations**
  - Use for the **ISO** method only.

In the FlowTracker real-time display, uncertainty is shown with the calculated discharge; the largest individual source of uncertainty is also shown. The *FlowTracker* software program shows both uncertainty calculations and the contribution of each parameter to the overall uncertainty. A complete description of the discharge uncertainty calculations can be found in the *FlowTracker Technical Manual*.

2.2. Discharge Data Collection Procedure

This section outlines a typical procedure when collecting data in the **Discharge Mode**. The actual sequence of steps may vary based on your application. Table 2-2 lists the items shown on the display screen during data collection.

Table 2-2. Data Collection Display Items

Label	Description	English	Metric
RatedQ	Rated discharge (as input by the user)	ft^3/s	m^3/s
TotalQ	Computed discharge (based on FlowTracker measurements)	ft^3/s	m^3/s
Loc	Location	ft	m
Dep	Water depth	ft	m
0.6, 0.2/0.8, *etc.*	Velocity method; §2.1.4	-	-
0.6(0.32)	Measurement depth • Fractional depth is first – e.g., **0.6** indicates 0.6 * depth down from the surface. • Actual depth (in parenthesis) is second. This is referenced from the bottom up and includes the effect of ice, if present.	ft	m
Vel	X velocity component	ft/s	m/s
SNR	Signal-to-noise ratio; §5.1	dB	dB
Time	Time remaining in average		
σV	Standard error of velocity; §5.1	ft/s	m/s
Spikes	Number of spikes removed from mean; §5.1	-	-
Bnd	Boundary QC value; §5.1	-	-
NPts	Number of points collected		
Ang	Flow angle relative to X direction; §5.1	°	°
StnQ	Station discharge	ft^3/s	m^3/s
StnV	Mean station velocity; §2.1.4	ft/s	m/s
%Q	Station discharge as percent of either rated or measured discharge, based on the discharge **Reference** value.	%	%

The following steps describe the data collection sequence when in **Discharge Mode**.

1. Run pre-deployment diagnostics before taking the instrument to the field (§1.9).
2. Check **Setup Parameters.**
3. From the **Main Menu**, press **3** to **Start Data Run**.
4. Specify file name and extension (or press **Abort** or **End Section** to return to the **Main Menu**).
5. Enter site and operator name; these are optional values used only to document the data set.
6. At any point, press **QC Menu** to access a variety of special functions (§1.8).
7. You are prompted to conduct an automatic QC test (§1.7.1). SmartQC
    a. Press **1** to run the automatic QC test, and follow on screen instructions.
    b. Press **2** to skip the test and begin data collection.
8. Starting-edge information will be displayed (right).
    a. Press **Set Location** to set starting-edge location (**Loc**).
    b. Press **Set Depth** to set starting-edge water depth (**Dep**).
    c. Press **Corr. Factor** to set any required correction factor (**CF**); see §2.1.4.

```
   Starting Edge
Loc 1.00    Dep 0.50
LEW         CF 1.00
 Press Next Station
```

   d. Press **LEW/REW** to toggle the starting edge of water (left or right).
   e. When complete, press **Next Station** to continue.

9. Station information will be displayed (right).
   a. Press **Set Location** to set station location (**Loc**).
   b. Press **Set Depth** to set water depth (**Dep**).
   c. Use **Method+** and **Method–** to select the method used for velocity at that station (§2.1.4).

```
Stn 1          Loc 2.00
0.6            0.6(0.54)
               Dep 1.35
              Enter=More
```

10. When all values are specified and the probe is in position, press **Measure**.
11. When the station is complete, a summary of velocity and quality control data is shown (right).
    a. Data are automatically reviewed using several quality control criteria (§5.1). If any data are outside expected values, a warning is issued.
    b. The values represent the mean over the entire averaging period after removing any spikes.
    c. Press **1** to accept the measurement and move on to the next measurement.
    d. Press **2** to repeat the measurement (using the same station number).

```
Vel 2.25       σV 0.04
Ang 5°        SNR 15.1
Spikes 0       Bnd BEST
1:Accept       2:Repeat
```

12. If there is more than one measurement at a station (e.g., method 0.2/0.8), the system proceeds to the next measurement in the series (e.g., 0.8).
    a. With **Multi Pt**, the FlowTracker allows any number of measurements for each station.
    b. When the last measurement is complete, press **End Section** or **Abort** to end that station.
13. When a station is completed, the FlowTracker displays the next station. Repeat Steps 9 through 12 to add additional stations.
14. Between stations, you can use **Next/Prev. Station** to scroll through completed stations.
    a. Stations are sorted based on location and displayed in that order.
    b. Four screens are available for completed stations; press **Enter** to scroll through screens.

```
Stn 1          Loc 2.00
0.6            0.6(0.54)
               Dep 1.35
              Enter=More
```

```
Stn 1          Loc 2.00
Npts 40        0.6(0.54)
Vel 2.25
Ang 5°        Enter=More
```

```
Stn 1          Loc 2.00
SNR 14.5       0.6(0.54)
σV 0.04        Bnd BEST
Spikes 0      Enter=More
```

```
Stn 1          Loc 2.00
StnQ 2.523 cfs
StnV 2.25 ft/s
%Q 4.5%       Enter=More
```

    c. Use **Calculate Disch.** to view the total discharge (**TotalQ**) for all completed stations (right). This is a temporary calculation and does not affect ongoing data collection.

```
TotalQ 44.234 cfs
RatedQ 45.000 cfs
Difference -1.7%
    Press Enter
```

15. It is possible to delete or repeat a station if desired.
    a. To delete an existing (completed) station:
       - Use the **Next Station** and **Previous Station** keys to scroll to the desired station.
       - Press the **Delete** key; when prompted, enter **123** to confirm the deletion.
    b. To repeat a station:
       - First, **Delete** the desired station.
       - Enter the location, depth, and measurement method of the station to be repeated.
       - The new station data automatically sorts to the correct position based on location value.
16. When all stations are completed, press the **End Section** key.
    a. The FlowTracker reviews all data using several quality control criteria (§5.1).

b. When the review is complete, the ending-edge screen is shown.
c. **Next Station** and **Previous Station** can be used to view/edit other stations.
   - To add new measurements, press the **Measure** key and confirm when prompted that you wish to re-open the file and add measurements.
d. When ready, press **Calculate Disch.** to complete discharge calculations and close the file.

17. After final discharge calculations are complete, nine screens of data are available.
    a. Press **Enter** to move between the different display screens (below and Table 2-3).
    b. Press **Prev. Station** from any file summary screen to view the station data; scroll through all station data using the **Next Station** and **Prev. Station** keys.
18. Press **0** to return to the main menu.

IMPORTANT: Return to the Main Menu before turning the system off to save all data.

TotalQ 44.234 cfs RatedQ 45.000 cfs Difference -1.7% 0=Exit or Enter=More	Q Uncertainty 3.5% Largest Source Num Stations 0=Exit or Enter=More	Num Stations 27 V Mean 1.43 ft/s V Max 2.21 ft/s 0=Exit or Enter=More
Width 23.000 ft Area 47.350 ft^2 0=Exit or Enter=More	Depth Mean 2.77 ft Depth Max 3.15 ft 0=Exit or Enter=More	SNR Mean 16.5 dB σV Mean 0.05 ft/s Temperature 61.2°F 0=Exit or Enter=More
Start Height 4.900 End Height 5.000 Change 0.100 ft 0=Exit or Enter=More	File 555312.100 Mode: Discharge 2001/06/25 14:24:15 0=Exit or Enter=More	Site Poudre River FC Operator Billy Bob 0=Exit or Enter=More

Table 2-3. Data Review Screen Details

Label	Description	English Units	Metric Units
RatedQ	Rated discharge	ft^3/s	m^3/s
TotalQ	Calculated discharge	ft^3/s	m^3/s
Q Uncertainty	Discharge uncertainty (§2.1.5)	%	%
Stations	Total number of stations (including edges)		
MeanV	Mean velocity (equals discharge / area)	ft/s	m/s
Max V	Maximum station velocity	ft/s	m/s
Width	Total width	ft	m
Area	Total area	ft^2	m^2
Mean Depth	Mean river depth (area / width)	ft	m
Max Depth	Maximum station depth	ft	m
MeanSNR	Mean signal to noise ratio; §5.1	dB	dB
MeanσV	Mean standard error of velocity; §5.1	ft/s	m/s
Temperature	Mean water temperature.	ºF	°C
Start / End Height, Change	First and last gauge height values, and the difference between the two; §1.8	ft	m
Site	Site name		
Operator	Operator name		

Section 3. General Mode Operation

The **General Mode** of data collection is for applications that need a series of current measurements at different locations, but do not require a discharge calculation. The following parameters are recorded with each measurement (none are required).

- Station number (automatically generated)
- Two location variables (**L1** and **L2**)
- Water depth (**Dep**)
- Measurement depth (**MDep**)

This section outlines a typical procedure when collecting data in the **General Mode**; the sequence of steps you use may vary based on your application. Table 3-1 lists the items shown on the display screens during data collection.

Table 3-1. Data Collection Display Screen Details (General Mode)

Label	Description	English	Metric
Stn	Station number		
L1	Location value 1	ft	m
L2	Location value 2	ft	m
Dep	Water depth	ft	m
MDep	Measurement depth	ft	m
Vx	X velocity component	ft/s	m/s
Vy	Y velocity component	ft/s	m/s
Vz	Z velocity component	ft/s	m/s
SNR	Signal-to-noise ratio (mean of all receivers); §5.1	dB	dB
Time	Time remaining in average		
σV	Standard error of velocity; §5.1	ft/s	m/s
Spikes	Number of spikes edited from mean; §5.1		
Bnd	Boundary QC value; §5.1		
NPts	Number of points collected (may differ from averaging time if **Abort** key used)		

The following steps describe the data collection sequence when in **General Mode**.

1. Run pre-deployment diagnostics before taking the instrument to the field (§1.9).
2. Check **Setup Parameters.**
3. From the **Main Menu**, press **3** to **Start Data Run**.
4. Specify file name and extension (or press **Abort** or **End Section** to return to the **Main Menu**).
5. Input site and operator name; these are optional values used only to document the data set.
6. At any point, press **QC Menu** to access a variety of special functions (§1.8).
7. You are prompted to conduct an automatic QC test (§1.7.1). SmartQC
   a. Press **1** to run the automatic QC test, and follow on screen instructions.
   b. Press **2** to skip the test and begin data collection.
8. Station information will be displayed (right).
   a. Press **Set Location** to set location 1 (**L1**) and location 2 (**L2**) values.
   b. Press **Set Depth** to set water depth (**Dep**).
   c. Press **Set Meas Depth** to set measurement depth (**MDep**).
   d. When the probe is located at the desired station, press **Measure** to start data collection.

```
Station 1
L1 0.00     Dep 0.00
L2 0.00    MDep 0.00
Press Meas to Start
```

9. When the station is complete, a summary of velocity and quality control data is shown (right).
   a. Press **1** to accept the measurement and move on to the next station.
   b. Press **2** to repeat the measurement (using the same station number).

```
Vx 2.25     σV 0.02
Vy 0.42     SNR 15.1
Spikes 0    Bnd BEST
1:Accept     2:Repeat
```

10. When a measurement is accepted, the FlowTracker displays the next station. Repeat Steps 6 through 9 to add additional stations.
11. Use the **Prev/Next Station** keys to scroll through completed stations. Three screens (below) are available for each completed station; press **Enter** to scroll through the screens.

```
Station 3
L1 4.00     Dep 2.25
L2 6.50    MDep 1.50
Press Enter For More
```

```
Stn 3      MDep 1.50
Vx 2.25    Vy 0.42
Vz 0.05    Npts 40
Press Enter For More
```

```
Stn 3      MDep 1.50
SNR 14.5    Bnd BEST
σV 0.02     Spikes 0
Press Enter For More
```

12. When all stations are done, press **End Section** to close the file and view summary data.
    a. Press **Enter** to move between the file summary screens (below and Table 3-2).
    b. Press **Prev Station** from any file summary screen to view station data; scroll through all station data using the **Next Station** and **Prev Station** keys.
    c. When done, press **0** to exit and return to the main menu.
    d. **Return to the Main Menu <u>before</u> turning the system off to ensure all data has been saved.**

```
File 555312.100
Mode: General
2001/06/25  14:24:15
0=Exit or Enter=More
```

```
Site
Poudre River FC
Operator Billy Bob
0=Exit or Enter=More
```

```
File 555312.100
Num Stations 15

0=Exit or Enter=More
```

```
Vx Mean 1.05 ft/s
Vy Mean 0.08 ft/s

0=Exit or Enter=More
```

```
Vx Min 0.88 ft/s
Vy Min -0.10 ft/s

0=Exit or Enter=More
```

```
Vx Max 1.63 ft/s
Vy Max 0.34 ft/s

0=Exit or Enter=More
```

```
SNR Mean 16.5 dB
σV Mean 0.05 ft/s
Temperature 63.2°F
0=Exit or Enter=More
```

Table 3-2. Summary Display Screen Details (General Mode)

Label	Description	English	Metric
Stations	Total number of stations (including edges)	-	-
Site	Site name	-	-
Operator	Operator name	-	-
Vx Mean	Mean X velocity	ft/s	m/s
Vy Mean	Mean Y velocity	ft/s	m/s
Vz Mean	Mean Z velocity (if present)	ft/s	m/s
Vx Min	Minimum X velocity	ft/s	m/s
Vy Min	Minimum Y velocity	ft/s	m/s
Vz Min	Minimum Z velocity (if present)	ft/s	m/s
Vx Max	Maximum X velocity	ft/s	m/s
Vy Max	Maximum Y velocity	ft/s	m/s
Vz Max	Maximum Z velocity (if present)	ft/s	m/s
SNR Mean	Mean signal to noise ratio; §5.1	dB	dB
σV Mean	Mean standard error of velocity; §5.1	ft/s	m/s
Temperature	Mean water temperature	°F	ºC

Section 4. FlowTracker Windows Software

The *FlowTracker* software is intended to be self-explanatory. The software can be found on the CD included with the system or downloaded from the SonTek/YSI website at www.sontek.com. Additional documentation is available in the software and the *FlowTracker Technical Manual*.

To install the *FlowTracker* software on your computer:

- Insert the distribution CD in your computer.
- An installation menu should automatically appear after the CD has been inserted.
- Click the **FlowTracker Software Installation** button and follow the instructions.
- *FlowTracker* software is compatible with Windows 2000 and XP.

The *FlowTracker* software serves several functions.

- Download data files using **Recorder**.
  - Connect the FlowTracker to a COM port on your computer and click **Connect.**
- Export data files and generate reports using **Open a FlowTracker File**.
  - Select data export options using **Program Settings**.
  - Several outputs are available.
    - **HTML Report**: A formatted report for easy viewing and printing.
    - **ASCII Discharge File** (**.DIS**): Final results in a form that is easy to integrate with database utilities.
    - **ASCII Summary File** (**.SUM**): Summary velocity and quality control data from all measurements.
    - **ASCII Raw Data File** (**.DAT**): Raw, one-second velocity and SNR data.
    - **ASCII Control File** (**.CTL**): System configuration data.
  - Output formats should be self-explanatory and include optional column headers.
- Export data files and generate reports for multiple files using **Open Many FlowTracker Files/Folders**.
- Detailed system diagnostic procedures using **BeamCheck**.
  - **BeamCheck** is a module used to evaluate all aspects of system operation (§4.1).
  - Connect the FlowTracker to a COM port on your computer and click **Connect.**

4.1. Diagnostic Software (BeamCheck)

BeamCheck (Figure 11) is a diagnostic program that is used to verify FlowTracker performance. This is the same diagnostic program used at SonTek; it provides you with a powerful tool for understanding and verifying system performance. We recommend you become familiar with this software and use it on a regular basis.

To run *BeamCheck*:

- Hold the FlowTracker in a bucket of water (or a natural environment) such that the probe is submerged and there is a boundary (surface, side, or bottom) within view.
    - Ideally, the boundary should be placed 20-30 cm (8-12 in) from the probe.
    - You may need to add a small amount of fine dirt or other seeding material and stir the bucket well for good test conditions. Regular tap water usually does not have enough scatterers (seeding) for a valid test.
- Connect the FlowTracker to the PC and turn the system on.
- Run the *FlowTracker* software (click **Start | Programs | SonTek Software | FlowTracker**).
- Click **Connect**.
- Select **BeamCheck** on the left side of the screen; now:
    - Click **Start**.
    - Click **Record** to save all data to a file. Typically, a minimum of 20 pings is required for proper data analysis.
    - Click **Averaging** to average multiple pings together.
- Figure 11 shows a sample output screen.

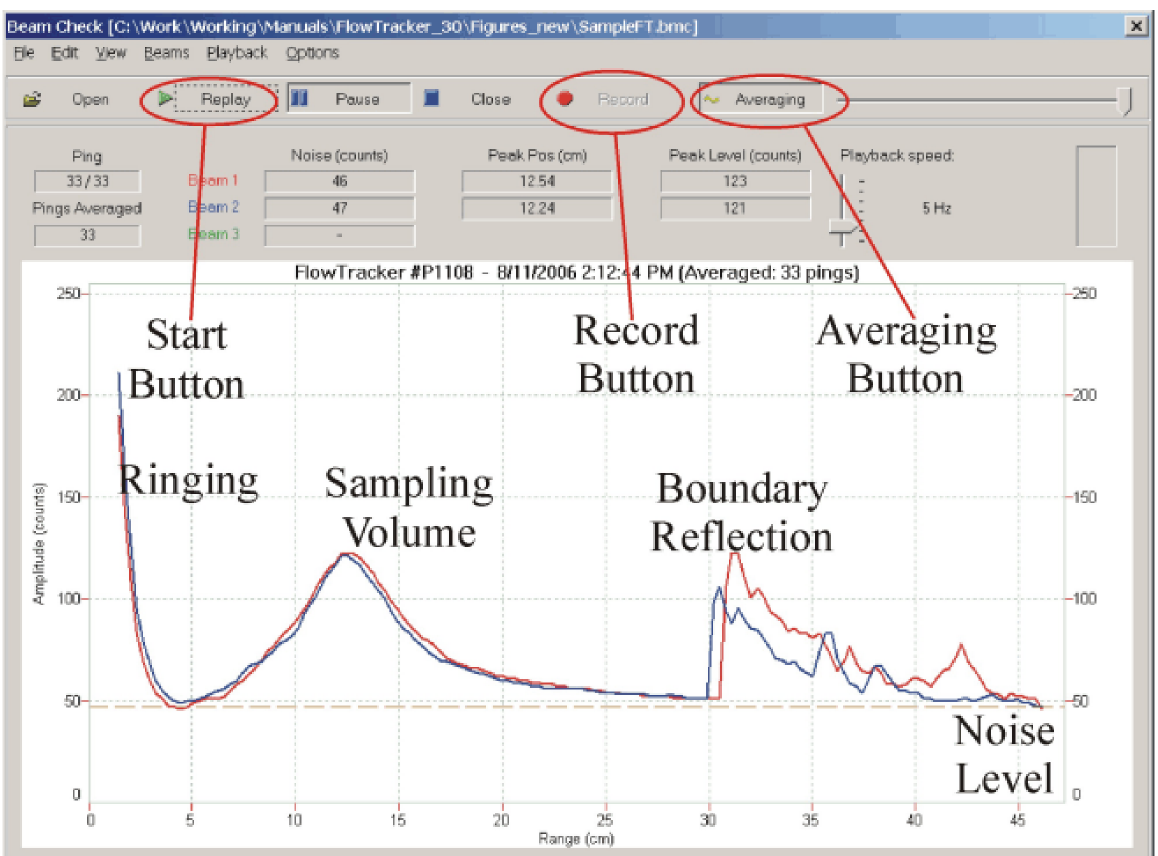


Figure 11 – BeamCheck Sample Output Screen

In *BeamCheck*, the FlowTracker sends a pulse of sound and outputs the return signal strength for each receiver as a function of time. Features in the signal strength profile verify different aspects of system performance (Figure 11).

- The horizontal axis indicates the range from the FlowTracker probe (in cm).
- The vertical axis is in internal signal strength units called counts (1 count = 0.43 dB).
- *Ringing* from the transmit pulse appears on the left side of the graph.
- The location of the *sampling volume* is indicated by increased signal strength in a bell-shaped curve.
  - The sampling volume curve corresponds to the transmit pulse passing through the focal point of the receivers.
  - The peak of this curve corresponds to the center of the sampling volume.
  - The location of the sampling volume varies, but is typically 10-12 cm.
  - All receivers (2 or 3) should see the peak in the same location, although there will be variation in the height and shape of the curve.
- A sharp spike indicates a *boundary reflection* (if a boundary is within range).
  - If the probe is close to a boundary, a sharp reflection should be seen.
  - The size and shape of this reflection will vary depending on the nature of the boundary and its distance from the FlowTracker.
- Signal strength decreases to the electronic *noise level* past the boundary.

When using *BeamCheck*, it is important to understand that the output plot will vary considerably because of the nature of acoustic scattering.

- Each of the above items should be visible (Figure 11).
- If no sampling volume peak can be seen, try adding some fine dirt or other seeding material and stirring the water to increase the signal strength.
- If the *BeamCheck* output differs significantly from the sample shown here, refer to the *FlowTracker Technical Manual* for more details about interpreting this data.

Section 5. Quality Control Data (SmartQC) and Troubleshooting

5.1. Quality Control Data SmartQC

The FlowTracker records quality control (QC) data with every measurement (Table 5-1). QC parameters are automatically reviewed with each measurement and at the completion of a discharge cross section. If any value exceeds expected criteria a warning is given. Table 5-2 displays different QC warning messages and gives guidelines for interpreting these messages. All QC review criteria can be adjusted or disabled.

5.1.1. Adjusting Quality Control Criteria SmartQC

All quality control criteria can be modified or disabled. To access quality control settings:

- From the **Main Menu**, press **1** for **Setup Parameters**.
- From **Setup Parameters**, select **4** for **QC Settings** (§1.6.1).
    - **SNR Threshold**, **σV Threshold**, **Spike Threshold**
- From **Setup Parameters**, select **5** for **Discharge Settings** (§1.6.2).
    - **Max Section Discharge**, **Max Depth Change**, **Max Location Change**, **Max Velocity Angle**

To disable any QC criteria, set that parameter to a value of **0**.

Table 5-1. Quality Control (QC) Parameters

Parameter	Description	Expected Values
SNR	**SNR** is the most important QC parameter. • It measures the strength of the acoustic reflection from particles in the water. • Without sufficient SNR, the FlowTracker cannot measure velocity.	Ideally > 10 dB Minimum ≥ 4 dB
σV	**σV** (standard error of velocity) is a direct measure of the accuracy of velocity data. • It includes the effects of turbulence in the river and instrument uncertainty.	Typically < 0.01 m/s (0.03 ft/s). Higher in turbulent environment.
Spikes	**Spikes** in FlowTracker velocity data are removed using a spike filter. • Some spikes are common and no cause for concern. • Too many spikes indicate a problem in the measurement environment (e.g., interference from underwater obstacles or highly aerated water).	Typically < 5% of total samples. Should be < 10% of total samples.
Angle	**Angle** is the direction of the measured velocity relative to the FlowTracker X-axis. • Used for discharge measurements only. • A good site should have small velocity angles. • Large angles may be unavoidable at some sites.	Ideally < 20º
%Q	**%Q** is the percentage of the total discharge in a single measurement station. • Most agencies have criteria for the maximum **%Q**.	Typical criteria: Ideally < 5% Maximum < 10%
Boundary QC	**Boundary QC** evaluates the measurement environment for interference from underwater obstacles. • **FAIR** or **POOR** results may indicate significant interference from an underwater obstacle.	**BEST** or **GOOD**

Table 5-2. QC Warning Messages

Warning	QC Criteria	Description	Suggested Action
Low SNR	**None**	SNR < 4 dB	• Improve SNR (§5.2)
Beam SNR	**SNR Threshold**	Difference in SNR for any 2 beams is > **SNR Threshold**.	• Look for underwater obstacles; repeat measurement. • Check probe operation (§4.1).
SNR Variation	**None**	One-second SNR data varies more than expected during a measurement. May indicate underwater interference or a highly aerated environment.	• Look for underwater obstacles; repeat measurement. • Look for environmental sources (e.g., aerated water).
SNR Change	**SNR Threshold**	SNR more than **SNR Threshold** different previous measurements; major change in measurement conditions.	• Look for underwater obstacles or other changes in river condition. • Repeat measurement
High σV	**σV Threshold**	**σV** > **σV Threshold**; adjusted based on previous data and measured velocity. May indicate interference or a highly turbulent environment.	• Look for underwater obstacles or a change in conditions. • Consider real turbulence levels in river. • Repeat measurement.
High Spikes	**Spike Threshold**	**Spikes** > **Spike Threshold** percent of samples. May indicate poor measurement conditions.	• Look for underwater obstacles or unusual conditions (e.g., aerated water). • Repeat measurement.
High Angle	**Max Velocity Angle**	**Angle** > **Max Velocity Angle**. May only indicate non-ideal measurement environment.	• Consider if measured angle is realistic. • Repeat measurement if needed.
High %Q	**Max Section Discharge**	**%Q** > **Max Section Discharge**. Station contains a large portion of the total discharge.	• Consider adding more stations.
Suspect Depth Value	**Max Depth Change**	Station depth differs from adjacent stations by more than **Max Depth Change** %. This may indicate a data entry problem.	• Verify station depth value. • Re-enter if needed.
Suspect Location Value	**Max Location Change**	Spacing between stations has changed by more than **Max Location Change** %. This may indicate a data entry problem.	• Verify station location value. • Re-enter if needed.
Location Out of Order / Location Outside Edge	**None**	Station location out of sequence or outside river edge. This may indicate a data entry problem.	• Verify station location value. • Re-enter if needed.
Bad Boundary QC	**None**	**Boundary QC** is **FAIR** or **POOR**. Indicates possible interference from underwater obstacles.	• Consider re-locating probe and repeating test. • Measurement can proceed if results are consistent.

5.2. Seeding

If velocity data appears "noisy" the most common cause is low SNR (a lack of scattering material in the water). Visual inspection is **not** an acceptable method for determining the amount of particles in the water and no simple relationship exists with turbidity. If you are unsure as to whether a stream is “too clear” for a FlowTracker, simply place it in the water to check the SNR values. See the *FlowTracker Principles of Operation* for details about how/why the FlowTracker uses scattering material for velocity measurements.

- If SNR is too low (< 4 dB), the FlowTracker cannot accurately measure velocity.
- In most field applications, there is sufficient scattering material naturally present.
- Large laboratory tanks may have low SNR.
- To check requirements, use the **Raw Velocity Data** from the handheld interface (§1.7).
  - Ideally, SNR > 10 dB.
  - At a minimum, SNR ≥ 4 dB.

In the field, seeding can be introduced by stirring the bottom (e.g., walking across the river upstream). In some situations, seeding material will need to be introduced. A practical seeding material is lime or pulverized limestone. Large bags are inexpensive and readily available from most hardware stores; the material is mixed with water prior to adding. A note of caution: repeated addition of lime may gradually increase the pH in a tank.

5.3. Velocity Data Appears Noisy or Unreasonable

If the velocity data from the FlowTracker does not appear reasonable, the following list may help establish the source of the problem.

- Low SNR is the most common problem. See §5.2 and the FlowTracker Principles of Operation for details about seeding requirements.
- Inspect the FlowTracker to be sure debris has not caught on the probe.
- Verify the FlowTracker mounting is stable.
- Consider any possible environmental influences, particularly flow interference from underwater structures or obstacles.
- Consider the measurement environment. Highly turbulent or highly aerated water will greatly affect FlowTracker operation.
- Consider the orientation of the probe with respect to the flow direction to be sure the probe is not causing flow interference in the sampling volume (§1.3).
- Run **BeamCheck** (§4.1); this can address all aspects of FlowTracker operation.

Appendix A. FlowTracker Principles of Operation

A-1. Introduction

The FlowTracker uses the proven technology of the SonTek/YSI Acoustic Doppler Velocimeter (ADV) from a simple handheld interface. ADV technology provides several advantages.

- Accurate velocity measurements in a remote sampling volume
- 2D or 3D velocity measurements (depending on probe configuration)
- Invariant factory calibration – no periodic recalibration required
- Excellent performance for low and high flows – accuracy 1% of measured velocity

This appendix presents a general overview of the operating principles the FlowTracker. To learn more, see the *FlowTracker Technical Manual* or contact SonTek/YSI.

A-2. The Doppler Shift

The Doppler principle says that if a source of sound is moving relative to the receiver, the frequency of the sound at the receiver is shifted from the transmit frequency. The most common example of this is a train whistle; the pitch sounds higher when the train is approaching and lower and when the train is moving away. The FlowTracker uses the Doppler shift by measuring the change in frequency of sound that is reflected off particles in the water.

A-2.1. Bistatic Doppler Current Meters

Figure 12 shows the FlowTracker probe, a *bistatic* Doppler current meter.

- Bistatic means separate acoustic transducers are used for transmitter and receiver.
- The receivers are mounted to focus at a fixed distance (10 cm; 4 in) from the probe.
- The beam intersection determines the location of the *sampling volume*.

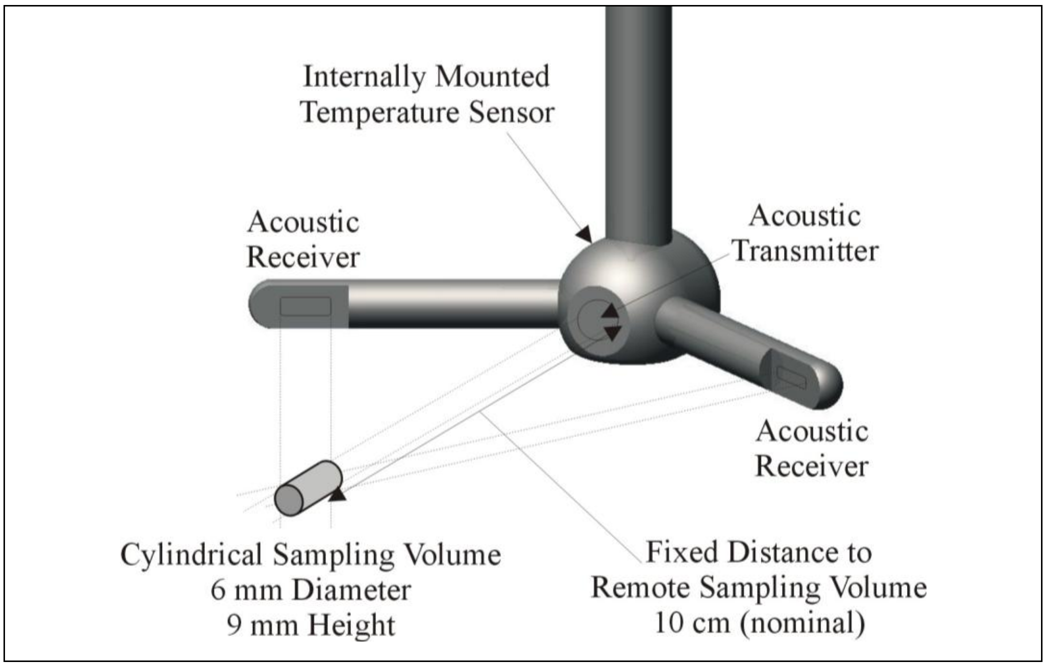


Figure 12 – FlowTracker 2D Side Looking Probe and Sampling Volume

The FlowTracker measures velocity as follows.

- The transmitter generates a short pulse of sound at a known frequency.
- As the pulse passes through the sampling volume, sound is reflected in all directions by particulate matter (sediment, small organisms, bubbles).
- The acoustic receivers sample the reflected signal.
- The FlowTracker measures the change in frequency (Doppler shift) for each receiver.

A-2.2. Beam Geometry and 3D Velocity Measurements

A single transmit/receive pair measures the projection of the water velocity onto the bistatic axis. The bistatic axis is halfway between the transmit and receive beam axes.

- The FlowTracker uses one transmitter and two or three receivers (for 2D or 3D probes).
- Bistatic velocities are converted to Cartesian (XYZ) velocities using the probe geometry (the relative angles of transmit and receive beams).
- Probe geometry is precisely determined by a calibration procedure.
- The calibration only needs to be performed once; no periodic re-calibration is required.

A-3. FlowTracker Data

The FlowTracker provides several important performance advantages.

- It can measure 2D or 3D water velocities from 0.0001 to 4.0 m/s (0.0003 to 13 ft/s).
- Velocity data is accurate to 1% of the measured velocity in a one-second sample.
- Velocity data can be used immediately without any post-processing corrections.
- The FlowTracker calibration will not change unless the probe is physically damaged.

The following describes the basic FlowTracker sampling strategy.

- One velocity sample is recorded each second.
- Velocity data are collected at each measurement location over the user-specified time. Raw one-second velocity, mean velocity, and quality control data are recorded.
- For river discharge measurements, the FlowTracker combines velocity data with station location, water depth, and other data to determine total discharge in real-time.

A-4. Quality Control Data

In addition to velocity, the FlowTracker records a variety of quality control data with each measurement station to quickly evaluate the quality of velocity data (§5.1).

- Standard Error of Velocity
- Signal-to-Noise Ratio (SNR)
- Spike Filtering
- Flow Angle
- Boundary Adjustment